

WISCONSIN GEOLOGICAL & NATURAL HISTORY SURVEY

The Wisconsin Geological & Natural History Survey (WGNHS), part of the University of Wisconsin-Madison's Division of Extension, performs basic and applied groundwater research and provides technical assistance, maps, and other information and education to aid in the management of Wisconsin's groundwater resources. The WGNHS groundwater program is complemented by the Survey's geology programs, which provide maps and research-based information essential to the understanding of groundwater recharge, occurrence, quality, movement and protection. The Survey distributes maps, reports and data related to Wisconsin's geology and groundwater. The Director of the WGNHS is a permanent member of the Wisconsin Groundwater Coordinating Council (GCC) and several WGNHS staff members serve on GCC subcommittees.



Examining an outcrop in southwest Wisconsin (photo by Carsyn Ames).

FY 2022 Highlights

(See [the WGNHS 2021 Year In Review](#); also see this [interactive project map](#) describing the projects in more detail.)

- Investigating groundwater quality in southwestern Wisconsin
- Evaluating methods to determine depth to bedrock in Wisconsin
- Acquiring airborne electromagnetic (AEM) geophysical data over large parts of northeast and southwest Wisconsin
- Investigating groundwater and water-level fluctuations in the Bayfield Peninsula and the Chequamegon-Nicolet National Forest
- Investigating Neonicotinoids in groundwater and surface water in Central Wisconsin
- Understanding relationships between bedrock structure and folding and arsenic and other contaminants in groundwater
- Conducting new bedrock geologic mapping in Dodge, Jefferson, Lafayette, and Grant Counties
- Conducting new Quaternary geologic mapping in Wisconsin's Driftless Area and in Jefferson and Bayfield Counties
- Conducting hydrogeologic research in southwest Wisconsin
- Investigating groundwater-surface water relationships in Wisconsin streams, lakes, and wetlands

- Upgrading Wisconsin's statewide groundwater monitoring network
- Upgrading and enhancing geoscience information delivery

Details of Ongoing Activities

Groundwater-Level Monitoring Network

The WGNHS continues to cooperate with the Department of Natural Resources and U.S. Geological Survey in the operation and maintenance of Wisconsin's statewide groundwater-level monitoring network. The WGNHS supports evaluation and maintenance of the monitoring network, aids in data collection, interpretation, and provides information to public and private clients. Recent grants from the U.S. Geological Survey's National Groundwater Monitoring Network program have injected over \$550,000 in new funding to repair and evaluate old wells, replace failing wells, and drill new wells in areas of the state lacking monitoring coverage. By 2022, these investments will have resulted in repairs or evaluations to 38 monitoring wells and the drilling of 17 new wells across 30 of Wisconsin's 72 counties. Of the roughly 100 wells in the long-term network, nearly half will have been evaluated, improved, or added thanks to this funding source, representing a generational upgrade to the monitoring network. The WGNHS' webpage dedicated to the monitoring network has also recently been updated and a new video documents the current activities and value of the network. Visit: <http://wgnhs.wisc.edu/water-environment/groundwater-monitoring-network>.

County and Local Groundwater Studies

Geologic and groundwater studies at county and local scales continue to be an important part of WGNHS programs. With funding from the federal STATEMAP program or local sources, WGNHS scientists initiated or carried out county or locally focused geologic and/or groundwater studies during 2021 in ten Wisconsin counties. New geologic mapping is the fundamental starting point for understanding groundwater resources in Wisconsin. Many of these studies will generate or have generated water-table maps or depth-to-bedrock maps. (Maps: <https://wgnhs.wisc.edu/maps-data/maps/>)

- **Southwest Wisconsin groundwater and geology (SWIGG) project.** The purpose of this project is to improve our understanding of groundwater quality in southwest Wisconsin (Iowa, Lafayette, and Grant Counties) and how groundwater quality is related to local hydrogeologic properties and well construction characteristics. Southwest Wisconsin is an area of shallow carbonate bedrock beneath generally thin soils. Due to the shallow fractured bedrock and the presence of minor karst features this area is considered very vulnerable to groundwater contamination, but prior to this study regional groundwater sampling has been sparse. Project objectives are to (1) evaluate private well contamination in three counties using indicator bacteria (total coliform and *E. coli*) and nitrate based on randomized synoptic sampling events; (2) assess well construction and geological characteristics (e.g., well age, depth to bedrock) that affect total coliform and nitrate contamination; and (3) identify the source of contamination in a subset of total coliform- and nitrate-positive wells using microbial tests that distinguish

between human, bovine, and swine fecal sources. This project was completed in early 2022 and the [administrative report](#) is freely available. Additional information about the project is at <https://wgnhs.wisc.edu/southwest-wisconsin-groundwater-and-geology-study-swigg/>.

- **Hydrogeology and groundwater flow model of Columbia County.** This multi-year study is a cooperative effort between the WGNHS and USGS, sponsored by the Columbia County Department of Land Conservation and the Wisconsin DNR. The project involved characterization of the county's groundwater system and included development of a groundwater flow model. The model is used extensively at the request of county officials to evaluate potential sources of poor groundwater quality in many private and public groundwater supply systems. A [technical report](#) on the model and hydrogeology of the county was released in 2021.
- **Bedrock controls over arsenic contamination in southeast Wisconsin.** WGNHS geologist Eric Stewart and colleagues [published research](#) showing a relationship between arsenic detection in groundwater and proximity to bedrock folds in the Beaver Dam area of Dodge County. The statistical approach they used is encouraging because it can not only be used to assess variables impacting arsenic detection, but can also be used to model the impact of well construction strategies that could reduce arsenic risk. This research was also featured in a [news story](#) on UW–Madison's website. A better understanding of bedrock arsenic sources will be useful for potential casing regulations that could dramatically lower the percentages of wells that produce drinking water with low to moderate levels of arsenic within the southeast Wisconsin study area (Fond du Lac, Dodge and Jefferson Counties).
- **Bayfield County Groundwater.** The thick sands in the [central Bayfield uplands](#) comprise an important groundwater recharge area, but the remote location and a water table more than 200 ft below land surface pose challenges to studying the local hydrogeology. In 2021, we continued to monitor two groundwater wells installed in the Bayfield County uplands in order to better understand regional groundwater flow there.
- **Depth-to-Bedrock Map of Dodge County, Wisconsin.** This [new map](#), a companion to the recently released bedrock geology map of Dodge County, Wisconsin ([M508](#)), shows thicknesses of deposits of unconsolidated materials above the bedrock. Across the county, depth to bedrock ranges from 0 feet, where bedrock is exposed, to over 250 feet within bedrock valleys. Areas with bedrock depths shallower than 20 feet are of particular importance for land-use planning and to the construction stone industry. Such areas are more susceptible to groundwater contamination and underlie about 17 percent of Dodge County, including the more-populated areas of the county. [The accompanying report](#) describes how the map was compiled and outlines limitations of the map.

- **Nitrate in groundwater at Waupaca, Wisconsin.** The City of Waupaca, Wisconsin, uses groundwater pumped from a network of seven high-capacity wells as its municipal water supply. Recent increases in the concentration of nitrate in the municipal water supply raised questions about the source of this contamination and whether it might eventually exceed standards for drinking water. This study combined geologic, hydrologic, land-cover, water-use, and water-quality data from the area with a groundwater-flow model to simulate and predict the effects of different land and water use on the concentration of nitrate in groundwater pumped from two of the city's municipal wells. The resulting tool supports decision makers who are tasked with land-use management and demonstrates a study design that could be applied to well-head-protection efforts elsewhere in Wisconsin's Central Sands region. The WGNHS released a [report](#) on this work in early 2022.

Regional Groundwater Studies

Regional groundwater studies usually span multiple counties. During 2021 the WGNHS was involved in several regional projects, including the following:

- **Depth-to-Bedrock Mapping in Wisconsin.**
Depth-to-bedrock maps show the thickness of unconsolidated materials overlying bedrock. These maps provide a key link between the underlying geology, groundwater flow, and land use and are important in guiding activities such as permitting, bridge construction, and the land application of waste products in sensitive areas. Given their role in guiding decision-making, the production of accurate depth-to-bedrock maps is critical. [A new WGNHS report](#) describes techniques for making the maps, identifies sources of data and evaluates their strengths and weaknesses, describes available tools and best practices for using them, and explains the concept of uncertainty—how it's measured, its importance in decision making, and ways of displaying it.
- **Hydrogeology of the Chequamegon-Nicolet National Forest (CNNF).**
WGNHS continued several groundwater studies in the CNNF. These include characterizing groundwater-surface water interactions of recently flooded [seepage lakes near Drummond, WI](#), and, as mentioned above, studying groundwater recharge in the sandy uplands portion of the Bayfield Peninsula. We also began a project along the [North Fork of the Yellow River](#) in Taylor County to improve understanding of the local hydrogeology and to document baseline water chemistry. Over the course of the year, the project team made regular visits to this



Collecting water samples in the CNNF.
Photo by Anna Fehling.

area to sample water, monitor water levels, and collect other varied hydrologic and geophysical measurements. In the fall, WGNHS sampled a combination of more than 150 lakes, streams, springs, and campground wells throughout the Chequamegon-Nicolet National Forest. This work contributes an updated reference point for establishing long-term records and for identifying trends of water quality conditions within the National Forest.

- **Advancing the use of nitrate findings to inform groundwater protection and improvement strategies.** UW-Extension agents in Wood and Portage counties, Portage County staff, and the WGNHS developed [this study](#) based on input from the Central Sands County Groundwater Collaborative (CSGCC). The overarching goal is to advance the use of historical nitrate and neonicotinoid findings to inform groundwater protection initiatives and improvement strategies by counties within the Central Sands Region of Wisconsin – particularly, Adams, Juneau, Marquette, Portage, Waushara, and Wood.
- **Geology and hydrogeology of the Rountree Formation in southwest Wisconsin.** The uppermost bedrock formations across much of SW Wisconsin are carbonate rocks of the Sinnipee and Prairie du Chien Groups. As those rocks chemically weather over geologic time, they produce a dense red residual clay known as the Rountree Formation. However, because the Rountree Formation is covered by younger sediment, very little is known about it. [This project](#) will evaluate the geographic distribution of this red clay layer across numerous counties in southwest Wisconsin; investigate its geologic and geochemical properties; and assess what—if any—role it plays in buffering the bedrock groundwater system from surface contamination. The results of this investigation will merge with water quality data from the Southwest Wisconsin Groundwater and Geology (SWIGG) study to better understand the interaction between human land use, underlying geology, and groundwater contamination susceptibility in southwest Wisconsin.



Core of material from the Rountree Formation in southwest Wisconsin.

Groundwater Research Activities

The WGNHS carries out specific groundwater research projects focused on understanding topics important to groundwater use and management in Wisconsin and elsewhere. Active research projects during 2021 included the following:

- **Hydrogeology of Southwest Wisconsin.** The hydrogeology and hydrostratigraphy of the Driftless Region of southwestern Wisconsin are complex due to the presence of multiple bedrock aquifers, rugged topography, bedrock structures, and fractures and karst features. To begin to better understand this region the WGNHS has undertaken groundwater monitoring centered on the [Platteville Pioneer Farm](#), an Experimental Farm in Grant County operated by UW-Platteville. The goal of the Pioneer Farm work is to develop better conceptual models of the groundwater flow systems in SW WI.
- **Mapping depth to bedrock.** WGNHS scientists worked with DNR, DATCP, NRCS, and UW-Green Bay officials to develop and release [new guidance for depth-to-bedrock mapping in the state](#). An exciting offshoot of this project was the acquisition and interpretation of [airborne electromagnetic \(AEM\)](#) geophysical data over large parts of eastern Wisconsin. This work utilizes a helicopter-towed geophysical array to cover large land areas rapidly. Based on its success in eastern Wisconsin, WGNHS and partners are conducting a similar survey in parts of southwest and southeast Wisconsin in 2022.
- **Neonicotinoid contaminants in Wisconsin groundwater: relationships to landscape cropping systems.** WGNHS hydrogeologists are collaborating with researchers at the UW-Madison Department of Entomology to better constrain the temporal and spatial dynamics of neonicotinoids in stream water across the Central Sands Region and analyze potential linkages between land-use activity and neonicotinoid concentrations in streams. [Neonicotinoid monitoring results](#) in streams will be evaluated using a calibrated groundwater flow model for the Central Sands to delineate groundwater contributing areas to these streams. Agricultural land use patterns within the groundwater contributing areas will then be analyzed to develop statistical relationships between land-use type and neonicotinoid concentration in streams. These results will provide stakeholders an additional tool to assess risk to aquatic invertebrates, better protect sensitive taxa, and inform regulatory and land-use management decisions.



Helicopter towing a geophysical array hoop used for AEM surveys. Photo by Maureen Muldoon.

Groundwater Data Management and Support

In 2021 the WGNHS continued to collect geologic and groundwater data and provide this data to a variety of users. Significant databases and data efforts include the following:

- **Enhanced publications catalog.** The WGNHS maintains hundreds of reports, maps, and other records in digital form for free downloads to the public. During 2021 the Survey continued to upgrade the functionality of this service, allowing easier data searching, previewing and downloading of information related to Wisconsin's groundwater and geology.
- ***Collection of downhole geophysical logs.*** The WGNHS continually collects and compiles downhole geophysical logs from research wells and "wells of opportunity," such as municipal wells. The logs, including natural gamma radiation, temperature, caliper, fluid conductivity, borehole diameter and optical imaging, are important tools for understanding water-quality problems in individual wells, and for correlating geologic units in the subsurface. In addition to municipal wells, geophysical logging has been used to troubleshoot problems in private wells and wells owned by state agencies including Department of Corrections, Department of Natural Resources and Department of Transportation. The WGNHS maintains a publicly-accessible data viewer for geophysical logs and Quaternary core, see <https://data.wgnhs.wisc.edu/data-viewer/>.
- ***Hydrogeologic Data Viewer maintenance.*** The WGNHS continues to support the Hydrogeologic Data Viewer, a map-based application to access a statewide catalog of hydrogeologic data. The application provides DNR staff with online access to data and publications and includes several methods to search by area for data of interest, such as geologic and geophysical logs or well construction reports. Many of the geophysical logs are collected for the DNR in wells where water quality or lack of data is an issue.
- ***wiscLITH database.*** When requested, the Survey provides updates of the digital database, wiscLITH, which contains lithologic and stratigraphic descriptions of geologic samples collected in Wisconsin. This is a publicly available database, and current work efforts focus on including more data for areas of the state with active geologic and hydrogeologic projects. Database: <https://wgnhs.wisc.edu/pubs/wofr200903/>.
- ***Well construction reports.*** The WGNHS serves as the repository for well construction reports (WCRs) from wells installed between 1936 and 1989 and can provide digital or paper copies to those who request them. In addition, WGNHS serves as a point-of-contact for questions about WCRs and updates records when errors are found during project work.
- ***High-capacity well approval tracking.*** WGNHS continues to track high-capacity well approvals in an internal database. This enables a more proactive approach for WGNHS researchers, in collaboration with the DNR, to work with well drillers, pump installers and consultants to collect samples and borehole geophysical logs from priority areas of the state.
- ***WGNHS Research Collections and Education Center.*** The WGNHS archives geologic records, rock samples, core samples and other materials in Mount Horeb, Wisconsin. Our core repository contains over 2.5 million feet worth of drillhole

cuttings, more than 650,000 feet of drill core and more than 15,000 individual hand samples of rock from across the state. Examination tables and basic laboratory facilities allow convenient analysis and study of these materials by qualified individuals. More about the repository: <https://wgnhs.wisc.edu/research/core-repository/>.

Groundwater Education

WGNHS groundwater education programs for the general public are usually coordinated with the DNR or the Central Wisconsin Groundwater Center at UW–Stevens Point or with the UW–Madison science outreach community as well as with the UW-Madison Division of Extension. WGNHS produces and serves as a distributor of many groundwater educational publications through our website (<https://wgnhs.wisc.edu>). We also distribute information about Wisconsin groundwater on our website at <https://wgnhs.wisc.edu/water-environment>. Our outreach efforts reach different and broader audiences through a variety of social media tools, including:

- Facebook - <https://www.facebook.com/WGNHS>
- Twitter - <https://twitter.com/wgnhs>
- Pinterest - <http://www.pinterest.com/WGNHS/>
- YouTube - <https://www.youtube.com/channel/UCwwucf9-W1qocovGx-uzs7w>

WGNHS presents groundwater educational activities at various museums and schools and at UW-Madison outreach events (such as at Science Expeditions and at the Science Festival).

In 2021, WGNHS staff members participated in groundwater educational meetings in counties where mapping and/or hydrogeologic studies are in progress. Staff members will continue to work with the DNR and the Central Wisconsin Groundwater Center on teacher-education programs connected to the distribution of groundwater sand-tank models.

The WGNHS maintains a long commitment to the continuing education of water well drillers, pump installers and plumbing contractors through participation in the programs of the DNR and the Wisconsin Water Well Association. Geologic and hydrogeologic field trips and presentations for DNR water staff and new DNR employees have been held in the past and will continue as requested.

The WGNHS Research Collections and Education Center is providing a locale for various groups to conduct related educational programs. Researchers and consultants also use our core holdings in that collection to better understand the subsurface and its aquifers. Staff of WGNHS organize and annually present papers at the Wisconsin Section of the American Water Resources Association reaching consultants, academics, and state and federal agency scientists with results of our research.

For more information:

Visit <https://wgnhs.wisc.edu/>

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